TITLE OF THE INVENTION

~~Device for examining filled containers by means of X-rays and use of this device~~

DEVICE FOR EXAMINING FILLED CONTAINERS BY MEANS OF X-RAYS AND USE OF THIS DEVICE

CROSS-REFERENCE TO RELATED PATENT APPLICATIONS

~~Description~~

[0001] This patent application claims priority from patent application PCT/EP2003/012632 filed November 12, 2003, which claims priority from German Patent Application Number 202 17 559.6, which was filed on November 12, 2002, the entire content of which is herein incorporated by reference.

FIELD OF THE INVENTION

[0002] ~~The~~This invention relates to ~~a device for~~packaging. More particularly, it relates to examining ~~filled~~ containers for foreign bodies~~, such as glass splinters, with a transport apparatus for transporting the containers individually in succession in a row on a plane of transport, with an X-ray source for emitting an X-ray in a predetermined direction and with an apparatus for recording the X-rays after they have passed through the containers~~.

BACKGROUND OF THE INVENTION

[0003] The ~~checking~~examination of goods which are packed in containers, for example, fruit juices in ~~drinks~~drink bottles, by means of X-rays is a process known in the food industry. Problems arise when checking for foreign bodies ~~which~~that have a higher density than the packed goods and, therefore, fall to the bottom of the containers. In the case of containers with a dished bottom, as is the case with many ~~drinks~~drink bottles, the foreign bodies slide on the bulge of the container bottom to the inner container edge. There, they are hard to recognize by means of X-rays, as the

X-rays must penetrate not only the vertical container wall but also the bottom of the container~~, during which~~. During this process ~~they~~the bottles are oriented, because of the bulge of the container bottom, at an angle of, for example, 10° to the dished surface of the container bottom and therefore travel a very long distance inside the container material. An additional attenuation of the X-rays by any foreign bodies present therefore has only relatively little effect and is frequently no longer detectable. ~~On the other hand~~Also, unevennesses in the surface of the container bottom can easily be ~~taken~~mistaken for a foreign body.

[0004] ~~It is known from~~ EP-A-0 795 746~~, to solve this problem, to examine~~ discloses examining the containers using two X-rays, one of which points 45° in the direction of transport and the other of which points 45° against the direction of transport, with the result that they are at right angles to each other.

[0005] ~~It is known from~~ EP-A-0 961 114 ~~to turn~~discloses turning the containers upside down for this examination~~, with the result~~ so that any foreign bodies present drop down to the top of the container near the closure ~~and~~where they can be recognized with certainty by means of X-rays~~ as they do so~~.

[0006] ~~It is known from~~ WO 01/44791 ~~to tilt~~discloses tilting the containers sideways by roughly 80° and then ~~examine~~examining them for foreign bodies using a vertically directed X-ray.

BRIEF SUMMARY OF THE INVENTION

[0007] The invention is directed to a device for examining containers for foreign bodies. In an embodiment, the device comprises a transport apparatus for transporting the containers individually, in succession, in a row on a plane of transport. An X-ray source for emitting an X-ray in a predetermined direction and an apparatus for recording the X-rays after they have passed through the containers are also included.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. 1 is a front view of an embodiment of a device according to the invention wherein the X-ray is directed downward at the container at an angle of 30° towards the plane of transport;

[0009] FIG. 2 is a front view of an embodiment of a device according to the invention wherein the X-ray is directed upward at the container at an angle of 30° towards the plane of transport;

[0010] FIG. 3 is a front view of an embodiment of a device according to the invention with two X-rays directed at the container; and

[0011] FIG. 4 is a side view of the device of FIG. 3.

DETAILED DESCRIPTION OF THE INVENTION

[0012] ~~The object of~~ As shown in FIGS. 1-4, the invention is ~~to improve the reliability of the recognition~~directed to an apparatus for the detection of foreign bodies in filled containers. The apparatus will now be described in detail with reference to the figures.

~~According to the invention this object is achieved in the case of a device of the type mentioned at the outset in that the direction in which the X-rays are emitted from the X-ray source is inclined by between 10° and 60°, preferably 15° and 45°, and in particular approximately 30° to the plane of transport.~~

[0013] In an embodiment, as shown in FIGS. 1-4, the containers are drink bottles 10 which, in the lower area, have a cylindrical wall 12 and a dished bottle bottom 14. In an embodiment, the bottles 10 are constructed of glass. The bottles 10 are transported standing upright on a transport apparatus 16. The top of the transport apparatus 16 defines a plane of transport. The transport apparatus 16 can be a customary link-chain conveyor with plastic chain links. If the chain links interfere on the X-ray image, a belt conveyor can be used in which the containers 10 are transported by means of two laterally engaging belts. In belt conveyor transport apparatuses, as disclosed in EP-A-0 124 164, the bottom 14 of the containers 10 is not supported. In a belt conveyor transport apparatus, the plane of transport is defined by

the container bottoms 10. It preferably lies horizontal. However, it can also be inclined, particularly when using a belt conveyor.

[0014] ~~A suitable X-ray source produces~~An X-ray source 18 is arranged at a distance next to one side of the transport apparatus 16. The X-ray source 18 may produce x-rays 24 of any suitable energy level. Suitable X-ray sources 18 may produce, for example, an X-ray 24 with 50 to 100 keV~~, in particular with 60 keV~~. In an embodiment, a 60 keV X-ray source 18 is used. Dished container bottoms 14 generally have a maximum slope of between approximately 10° and 60° at the edge. ~~The~~Therefore, in an embodiment, the X-ray source 18 is positioned such that, at the point of the maximum slope of the container bottom 14 – which is generally at the edge of the container bottom 14 – the course of the X-ray 24 is roughly tangential to the bulge of the container bottom 14, as shown in FIGS. 1-3. This can be achieved by having an X-ray source 18 arranged ~~both~~either above the plane of transport ~~and~~or below the plane of transport. In either case, the X-rays 24 are preferably aligned roughly at a right angle to the direction of transport.

[0015] An apparatus for recording the X-rays 24 is on the other side of the transport apparatus 16. The apparatus for recording the X-rays 24 is arranged on the side of the transport apparatus 16 lying opposite the X-ray source 18. This apparatus can be a line of X-ray detectors or a two-dimensional field of X-ray detectors. In an embodiment, the X-ray detectors are photodiodes with a scintillation crystal. In another embodiment, the recording apparatus is an area sensor, for example, an X-ray image converter 20 or an X-ray image intensifier, with a downstream photographing device such as a CCD camera 22. Through the use of such an area sensor, the necessary exposure time is minimized and the exposure of the product and the environment to the ray is thus reduced.

[0016] If the X-ray source 18 is arranged above the plane of transport, the upper part of the X-ray 24 travels, in the area of the inner edge of the container bottom 14 facing away from the X-ray source ~~of the container bottom,~~18, approximately tangentially to the bulge of the container bottom 14. As a result, the X-ray 24 penetrates the material of the container 10 only on the front and on the back of the wall 12, but does not travel an extended distance inside the container bottom 14. If the inclination is, for example, 30°, the section inside the vertical container wall 12

increases by only approximately 15%. Consequently, the contrast of intensity differences that is caused by foreign bodies is reduced only to an insignificant extent.

[0017] Similarly ~~favourable~~favorable conditions apply in the area of the inner edge of the container bottom 14 facing the X-ray source ~~of the container bottom.~~18. Here the container bottom 14 rises at an angle of, for example, 30°, and so the X-ray 24 then travels at an angle of 60° to the container bottom, with the result being that here too the distance travelled is extended by only approximately 15% compared with an incidence at a right angle.

~~The X-ray can also be directed from below at an angle of for example 30° to the plane of transport towards the container bottom. In the area facing the X-ray source, the X-ray then travels approximately tangentially to the bulge of the container bottom, whereas in the area edge facing away from the X-ray source of the inner edge of the container bottom it then travels, in the chosen case, at an angle of approximately 60° to the container bottom.~~

~~In every case the X-rays are preferably aligned roughly at a right angle to the direction of transport.~~

~~In a particularly preferred version of the invention, the containers are examined using two X-rays, one of which is directed from above, and the other from below, towards the container bottom. Both X-ray sources are preferably arranged on the same side of the transport apparatus. The angles at which the X-rays are directed towards the container bottom can be the same or different. They are preferably approximately 30°. It is also possible to use still further X-ray sources, for example a third X-ray source which directs an X-ray parallel to the plane of transport or at a different angle from the first and second X-ray sources onto the container bottom. The angle of the X-rays to the direction of transport can also be different.~~

~~The apparatus for recording the X-rays is arranged on the side lying opposite in relation to the direction of transport of the X-ray source. This apparatus can be a line or a two dimensional field of X-ray detectors. The X-ray detectors can be~~

photodiodes with a scintillation crystal. However, the recording apparatus is preferably an X-ray image converter or X-ray image intensifier with downstream CCD camera. Through the use of such an area sensor, the necessary exposure time is minimized and the exposure of the product and the environment to the ray thus reduced.

An apparatus for recording the X-rays and for evaluating the items of information is allocated to each X-ray source. By comparing the information supplied by the individual recording apparatuses, a three-dimensional position determination of the defects is possible, as a result of which foreign bodies can be distinguished from defects in the material of the container wall.

When using two X-rays, the images are preferably coupled on an area sensor. The divergence angle of the X-rays and the distance between the X-ray sources and the transport apparatus on one side and the distance between the area sensor and the transport apparatus on the other side are matched to each other such that the image produced by the X-ray coming from below appears in the upper half of the area sensor, while the image produced by the X-ray coming from above appears in the lower half of the area sensor. Defects which emerge in one image can be sought and confirmed in the other image.

The transport apparatus can be a customary link-chain conveyor with plastic chain links. If the chain links interfere on the X-ray image, a belt conveyor can be used in which the containers are transported by means of two laterally engaging belts. Such a transport apparatus is known from EP-A-0 124 164. The bottom of the containers is not supported. The plane of transport is defined by the container bottoms. It preferably lies horizontal. In particular when using a belt conveyor, it can however also be inclined.

The subject-matter of the invention is also the use of the previously described device for examining filled containers for foreign bodies, in particular glass bottles with a dished bottom. The X-ray source or the X-ray sources are preferably positioned such that, at the point of the maximum slope of the container bottom, the course of the ray is roughly tangential to the bulge of the container bottom.

~~Embodiments of the invention are explained below with the help of the drawing. There is shown in:~~

~~Fig. 1 an embodiment in which the X-ray is directed from above at an angle of 30° towards the plane of transport;~~

~~Fig. 2 an embodiment in which the X-ray is directed from below at an angle of 30° towards the plane of transport;~~

~~Fig. 3 an embodiment with two X-rays viewed in the direction of transport and~~

~~Fig. 4 the embodiment of Fig. 3 in side view.~~

~~In the embodiments the containers are in each case glass drinks bottles 10 which, in the lower area, have a cylindrical wall 12 and a dished bottle bottom 14. The bottles 10 are transported standing upright on a transport apparatus 16. The transport apparatus 16 is a customary link chain conveyor. A 60 keV X-ray source 18 is arranged at a distance next to the transport apparatus 16 on one side, and on the other an apparatus for recording the X-rays. This apparatus is an area sensor in the form of an X-ray image converter 20. The image produced by the X-ray image converter 20 is recorded by a CCD camera 22.~~

[0018] ~~The top of the transport apparatus 16 defines a plane of transport. In the embodiment of Fig. 1~~In the embodiment shown in FIG. 1, the X-ray 24 is inclined by an angle of 30° ~~from above~~down towards the plane of transport. The distance between the X-ray source 18 and the transport apparatus 16 is approximately 30 cm and the X-ray 24 has a divergence of 15°, with the result that the whole bottle bottom~~,~~ 14, which has a diameter of approximately 7 cm, lies within the X-ray 24. The X-ray image converter 20 is arranged at the smallest possible distance next to the transport apparatus 16 and covers at least the area of the X-ray 24 which has penetrated the bottle bottom 14.

[0019] In the ~~represented~~ embodiment ~~of Figs~~shown in FIG. 1, there is a foreign body 26, for example, a glass splinter, on the side facing away from the X-ray source

18 of the inner edge of the bottle bottom 14. The foreign body 26 absorbs or scatters the X-rays 24 and can be recognized on the X-ray image converter 20 as a dark spot 32. As can be seen in ~~Fig~~FIG. 1, the rays in the immediate vicinity of the rays which strike the foreign body 26 penetrate the front and back of the wall 12 of the bottle 10 at an angle of approximately 60°. This also applies to the rays travelling immediately thereunder, which travel approximately tangentially to the bulge of the edge of the bottle bottom 14. On the other hand, the rays lying ~~even~~ somewhat deeper travel a relatively long distance inside the bottle bottom 14 and are thereby very markedly attenuated~~, unevennesses~~. Unevennesses in the top or bottom of the bottle bottom 14 ~~having~~has a particularly marked effect on the deeper rays. The rays in the immediate surroundings of the foreign body 26 are very uniformly attenuated, however, with the result being that the foreign body 26 can be recognized through a clear brightness contrast on the X-ray image converter 20.

[0020] The X-ray 24 can also be directed from below at an angle of, for example, 30° to the plane of transport towards the container bottom 14. In the area of the edge of the container bottom 14 facing the X-ray source 18, the X-ray 24 then travels approximately tangentially to the bulge of the container bottom 14, whereas in the area of the inner edge of the container bottom 14 facing away from the X-ray source 18, it then travels, in the chosen case, at an angle of approximately 60° to the container bottom 14.

[0021] In the embodiment ~~of Fig~~shown in FIG. ~~2~~2, the X-ray source 18 is arranged below the plane of transport, and the X-ray 24 is directed at an angle of 30° ~~from below~~upward towards the plane of transport. The same foreign body 26 as in ~~Fig~~FIG. 1 also stands out clearly against its surroundings in this case. The resulting angle at which the rays in the area surrounding the ray striking the foreign body 26 are directed towards the bottle bottom 14 is 30° ~~+~~plus the slope of the edge of the bottle bottom 14, which is typically also 30°. Any unevennesses in the material thickness in the bottle 10 thus ~~have~~has only a slight effect. As regards the arrangement of the X-ray image converter 20 and the CCD camera 22, the embodiment of ~~Fig~~FIG. 2 corresponds to that of ~~Fig~~FIG. 1.

[0022] The conditions as regards the course of the X-rays 24 to the bulge of the bottle bottom 14 and to the container walls 12 are transposed in the embodiments of

FIGS. 1 and 2 if the foreign body 26 is located on the side of the bottle bottom 14 facing toward the X-ray sources 18 instead of on the side facing away from the X-ray sources 18 of the bottle bottom 14.

[0023] In an embodiment of the invention, the containers are examined using two X-rays 24. In this embodiment, one of the X-rays 24 is directed towards the container bottom from above, and the other X-ray 24 is directed towards the container bottom from below. Both X-ray sources 18 are preferably arranged on the same side of the transport apparatus 16. The angles at which the X-rays 24 are directed towards the container bottom 14 can be the same or different. They are preferably approximately 30°. It is also possible to use still further X-ray sources 18, for example a third X-ray source 18 which directs an X-ray parallel to the plane of transport or at a different angle from the first and second X-ray sources 18 onto the container bottom 14. The angle of the X-rays 24 to the direction of transport can also be different.

[0024] FIGS. 3 and 4 illustrate an embodiment in which two X-ray sources 18 are provided. As shown in FIGS. 3-4, the X-ray 24 emitted from the first X-ray source 18 arranged above the plane of transport is directed downward towards the plane of transport at an angle of 30°. The second X-ray source 18 is arranged below the plane of transport, and the X-ray 24 emitted from it is directed upward towards the plane of transport at an angle of 30°.

[0025] ~~In the embodiment of Figs. 3 and 4, two X-ray sources 18 are provided, the X-ray 24 emitted from the first X-ray source 18 being directed at an angle of 30° from above towards the plane of transport, while the second X-ray source 18 is arranged below the plane of transport and the X-ray 24 emitted from it is directed at an angle of 30° from below towards the plane of transport. The~~When using two X-rays 24, the images are preferably coupled on an area sensor. The divergence angle of the X-rays 24 and the distance between the X-ray sources and the transport apparatus 16 on one side and the distance between the area sensor and the transport apparatus 16 on the other side are matched to each other such that the image produced by the X-ray 24 coming from below appears in the upper half of the area sensor, while the image produced by the X-ray 24 coming from above appears in the lower half of the area sensor. Defects which emerge in one image can be sought and confirmed in the other image. As shown in FIGS. 3-4, the distance between the X-ray sources 18 and the

transport apparatus ~~and~~16, the divergence of the emitted X-rays ~~24~~24, and ~~also~~ the size of the X-ray image converter 20 and its distance from the transport apparatus 16 are chosen such that the first image 28 produced by the first X-ray 24 is located in the lower half of the X-ray image converter 20 and the second image 30 produced by the second X-ray 24 is located in the upper half of the X-ray image converter 20. ~~The~~ In FIGS. 3-4, the foreign body 26 is again arranged as in ~~Figs~~FIGS. 1 and ~~2~~2, and it produces a spot 32 of reduced brightness both in the first image 28 and in the second image 30. ~~Both~~ In an embodiment, both images are taken using a single CCD camera 22. ~~The precise spatial position of the foreign body 26 can be established, using customary image-processing methods, from the position of the two spots 32. If this position lies on the outside of the wall 12 of the bottle 10, it can be concluded from this that it is not a foreign body 26 inside the bottle 10, but for example a raised point on the outside of the wall 12. The bottle 10 is then not defective.~~

~~The conditions as regards the course of the X-rays 24 to the bulge of the bottle bottom 14 and to the container walls 12 are transposed in the embodiments of Figs. 1 and 2 if the foreign body 16 is located, not on the side facing away from the X-ray sources 18 of the bottle bottom 14, but on the side facing them of the bottle bottom 14.~~

[0026] An apparatus for recording the X-rays 24 and for evaluating the information is allocated to each X-ray source 18. By comparing the information supplied by the individual recording apparatuses, a three-dimensional position determination of the defects is possible, as a result of which foreign bodies can be distinguished from defects in the material of the container wall 12. The precise spatial position of the foreign body 26 can be established from the position of the two spots 32 using customary image-processing methods. If this position lies on the outside of the wall 12 of the bottle 10, it can be concluded from this that it is not a foreign body 26 inside the bottle 10 but may be, for example, a raised point on the outside of the wall 12. The bottle 10 is then not defective.

As regards the accuracy of recognition and the sharpness of contrast of the spot 32 of reduced intensity caused by the foreign body 26 on the X-ray image converter 20, the same conditions ~~obtain~~are obtained in the embodiment of FIG. 1 as for the first image 28 ~~as in the embodiment~~ of ~~Fig~~FIG. ~~1~~,3, and the same conditions are obtained as in

the embodiment of ~~Fig~~FIG. 2 in the case of the second image 30. The conditions are again transposed if the foreign body 26 is located on the side of the bottle bottom 14 facing the X-ray sources ~~18of the bottle bottom 14.~~18.

[0027] The subject-matter of the invention is also the use of the previously described device for examining filled containers 10 for foreign bodies 26, in particular glass bottles 10 with a dished bottom. The X-ray source 18 or the X-ray sources 18 are preferably positioned such that, at the point of the maximum slope of the container bottom 14, the course of the ray is roughly tangential to the bulge of the container bottom 14.

What is claimed is:

~~List of reference numbers~~

~~10 Bottle~~

~~12 Wall~~

~~14 Bottle bottom~~

~~16 Transport apparatus~~

~~18 X-ray source~~

~~20 X-ray image converter~~

~~22 CCD camera~~

~~24 X-ray~~

~~26 Foreign body~~

~~28 First image~~

~~30 Second image~~

~~32 Spot~~

~~Patent claims~~